Appendix A

RX-AVC: Automatic Volume Control Algorithm

(Internal distribution only)

1 Background

The RX-AVC is an advanced audio function that automatically controls the received speech level and dynamic range. The AVC is a collection of 3 functions. The 3 functions can be activated both separately and together. The 3 functions are:

1. Automatic gain control (AGC)
2. Automatic volume increase and dynamic range compression (DRC) as a function of TX noise level
3. Dynamic range compression (DRC) for speakerphone

The following block diagram shows how the RX-AVC fits within the other speech modules in the RX and TX paths.

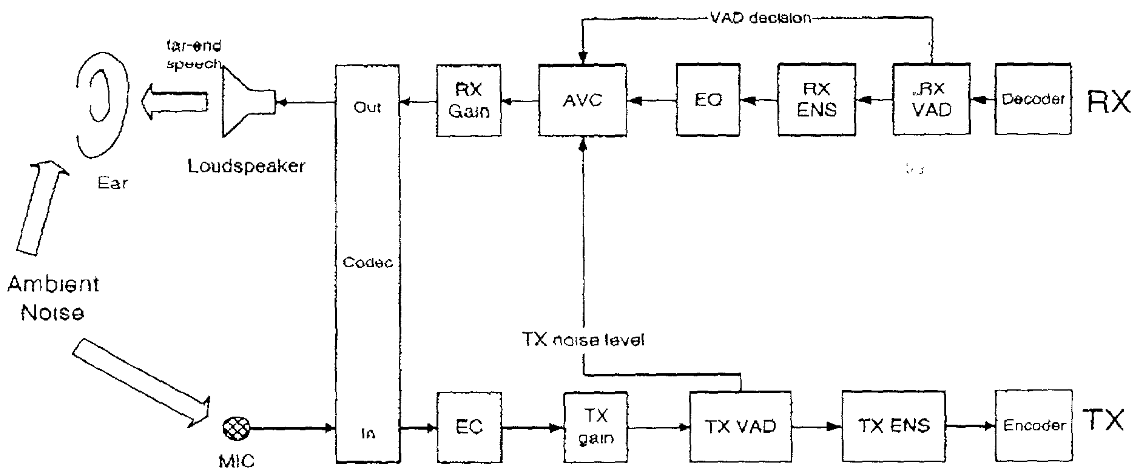

Figure 1: Audio path with RX-AVC.

2 Algorithm description

The total AVC gain is the sum of 3 gains:

1. AGC
2. DRC gain weighted by a maximum between two numbers: (1) a weight proportional to the TX noise level, (2) DRC GAIN FACTOR.
3. Additional constant gain whose value is weighted by TX noise level

Enabling flags (AGC_FLAG and NOISE_RESPONSE_FLAGS) gate the AGC and the noise-weighted gains. Figure 2 shows the algorithm block diagram.

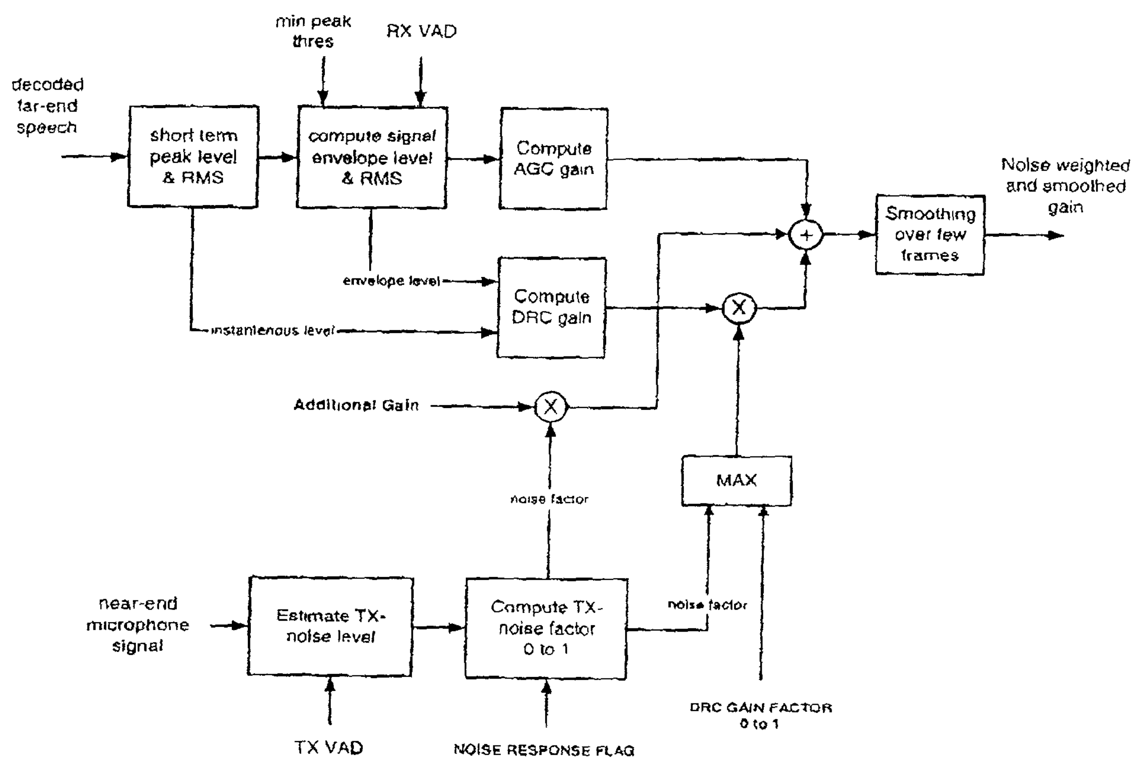

Figure 2: block diagram

2.1 Blocks description

2.1.1 short-term peak & short-term rms level

Computes maximal sample energy over a sub frame several samples (default=16)

Computes rms energy over the sub frame

2.1.2 Compute signal envelope level & speech-RMS

Envelope is updated if RX-VAD detected speech and if the local peak is above a threshold:

```
if (RX-VAD && local_peak > MIN_ENVELOPE)
{
   if (local_peak > envelope)
      envelope = min(local_peak, envelope + INCREMENT_PEAK) ;
   else
      envelope -= DECREMENT_PEAK ;

   if (rms > long_term_rms)
      long_term_rms += INCREMENT_RMS ;
   else
      long_term_rms -= INCREMENT_RMS ;
}
```

2.1.3 Compute AGC gain

Basic relation: agc_gain = (LEVEL1 - envelope) ;

Limitation 1: agc_gain = min(MAX_AGC_GAIN, agc_gain) ;

Limitation2: agc_gain = min(MAX_RMS - long_term_rms, agc_gain) ;

2.1.4 Compute DRC gain

Given the following noise dependent and RX- signal independent parameter:

drc_gain = MAX_DRC_GAIN * max(drc_gain_factor, noise_factor) ;

Compute for each sub-frame the following gain (frame_drc_gain) as a function of its local peak and the envelope level as depicted in the following figure:

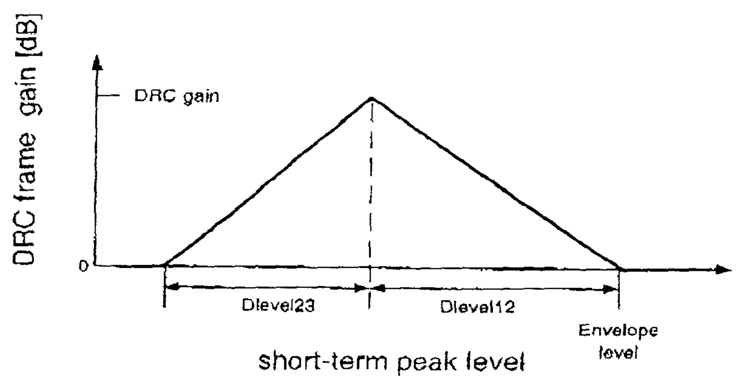

Figure 3: DRC gain function

2.1.5 Estimate TX noise level

See Period_alg.doc

2.1.6 Compute Noise factor

Noise factor is a function of noise level:

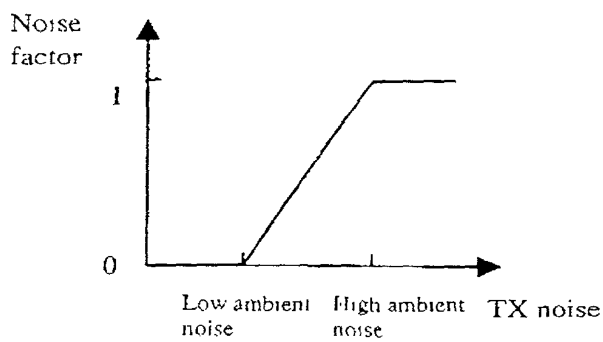

Figure 4: Noise factor

2.1.7 Gain smoothing

Signed exponential smoothing:

```
if (target_gain > smooth_gain_db)
      alfa = ALFA_UP ;
   else
      alfa = ALFA_DOWN ;

   smooth_gain_db = smooth_gain_db * (1-alfa) + alfa * target_gain ;
```

3 Parameters

3.1 Tunable parameters

AGC_FLAG

AGC enable/disable control bit

NOISE_RESPONSE_FLAG

Enable/disable control bit for the ambient noise-induced automatic volume increase.

DRC_GAIN_FACTOR

Controls the amount of DRC, ranging from 0 to 0x7FFF. Defaul = 0.

LEVEL1

Target level for the RX-signal envelope level. Default value: -3 dBov (3 dB below clipping level).

HIGH/LOW_AMBIENT_NOISE:

See figure 3. The default values are –39 dBov (low) and –21 dBov (High). Increasing these thresholds will reduce the effect of the RX-AGC to noise. The thresholds should be modified if the TX analog path gain is changed. For example, if the TX analog codec gain is increased by X dB, these thresholds should be increased by the same X dB.

MAX_AGC_GAIN

Upper limit on the AGC gain in the module "Compute AGC gain" (see 2.1.3). The default value is set to 21 dB.

MAX_DRC_GAIN

Upper limit on the DRC gain in the module "compute DRC gain" (see 2.1.4). The default value is set to its maximum allowed value of 21 dB. Decreasing this parameter will decrease the effect of the DRC.

MAX_RMS

The AGC gain is limited so that the signal RMS after amplification does not exceed MAX_RMS (default = -15 dBov).

MIN_ENVELOPE

Signals whose envelope is smaller than this threshold do not affect the AGC

3.2 Soft constants (default)

NUM_SUB_FRAMES	(10)
SUB_FRAM_LEN	(FRAM_LEN/NUM_SUB_FRAMES = 16)
LOG_SUB_FRAM_LEN	(10*log10(SUB_FRAM_LEN) = 12)
DLEVEL12 (see Figure 3)	(24)
DLEVEL23 (see Figure 3)	(26)
DECREMENT_PEAK	(3*SUB_FRAM_LEN/8000 = 3 dB/sec)
INCREMENT_PEAK	(1 = 1dB/sub_frame)
INCREMENT_RMS	(10*SUB_FRAM_LEN/8000 = 10 dB/sec)
ALFA_UP (see 2.1.7)	0.1)
ALFA_DOWN (see 2.1.7)	(0.5)